California Environmental Protection Agency

Air Resources Board

Draft – TEST PLAN FOR EVALUATION OF EVAPORATIVE AND EXHAUST EMISSIONS CONTROL TECHNOLOGY FOR OFF-HIGHWAY RECREATIONAL VEHICLES (OHRVs)

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I. Background

Evaporative emissions from OHRVs are a major source of hydrocarbon emissions in California. OHRVs includes off-road motorcycles, all terrain vehicles (ATVs), snowmobiles, and other specialty vehicles carts. Evaporative emissions from these categories can be broken down into three distinct sources:

- Permeation emissions through the fuel tank and fuel hose
- Vented emissions from the fuel tank
- Emissions from the carburetor and leaking connections

In 2002 the U.S. EPA adopted a regulation, set to be implemented in 2008, that controls permeation emissions from OHRVs. The reductions from the U.S. EPA regulation are limited because the regulation only controls a predicted 30 percent of diurnal emissions and has almost no effect on running loss emissions. Preliminary testing shows that a huge fraction of the total hydrocarbon emissions from OHRVs are from running loss. The ARB is developing a rule that will control permeation, vented, carburetor, and running loss emissions. Initial estimates predict that this ARB regulation can be up to 79 percent effective.

The current emissions inventory does not reflect actual emissions in California. ARB will re-evaluate the emissions factors, OHRVs usage, and OHRVs population to account for this discrepancy.

II. Plan Overview

Inventory Development

The current ARB emissions inventory is based on an old vehicle population and outdated emissions factors. The first step in developing a new emissions inventory is to develop new usage data for off-road motor cycles, ATVs, and snowmobiles. Usage data includes where, when, and how vehicles are being used and stored. ARB will develop new emissions factors by testing in-use and new OHRVs. A new population has already been developed. Usage, population, and emissions factors are combined to calculate the emissions inventory.

Control Technology Testing

To determine the efficiency level of evaporative emissions controls, OHRVs will be retrofitted with emissions control technology and subsequently tested. Emission factors that are generated with the retrofitted technology will be used to develop emissions inventories. These inventories represent predicted reductions. An important part of the emissions control technology evaluation is a safety and feasibility study. The OHRVs that are retrofitted with emissions control technology will be evaluated in an in-use safety and feasibility study.

Exhaust Emissions study

Exhaust emissions will be measured to quantify potential advantages of improved fuel management systems. Exhaust emissions will be measured from unmodified vehicles and then again from OHRVs with fuel injection and high efficiency catalysts. The feasibility and safety study is important because of increased exhaust temperatures associated with high efficiency catalysts.

III. Test Plan

Usage and Operation

Operation

To determine OHRVs usage, ARB will reference any available studies containing usage data. Data from these studies may be used as a comparison to data generated for the OHRVs program. OHRVs usage data will be generated by equipping in-use OHRVs that represents the population with data loggers. The data loggers will record the number of times the OHRVs starts and stops, and the total hours operated in a given period of time.

Storage

How OHRVs are stored has a large effect on evaporative emissions. End users will be surveyed to determine:

- How long OHRVs are stored.
- How the OHRVs are prepared for storage.
- Where the OHRVs are stored.
- What the fuel level is during storage.
- What type of fuel is used in OHRVs.

OHRVs Design

OHRVs tested as in-use will represent popular models sold in a specific age group. Variations in design that will affect evaporative emissions will be considered.

Inventory Development

Preliminary Equipment testing

Background and initial permeation emissions will be evaluated for new OHRVs. The background emissions will be measured over a 65℉-105℉ diurnal temperature profile on a OHRVs as it is received from the dealer. Initial permeation emissions will be evaluated by filling the fuel tank to half full, without allowing gas into the carburetor. The OHRVs will then be subjected to the same 24 hour diurnal test. Next the fuel in the tank will be allowed into the rest of the fuel system and the OHRVs will be subjected to the same 65℉-105℉ 24 hour diurnals e ach week until permeation emissions have stabilized. The preliminary equipment testing will show where the uncontrolled emissions are coming from.

Baseline Emissions

Baseline emissions will be measured for both evaporative and exhaust. ARB is quantifying exhaust emissions reductions because high efficiency catalytic converters can easily be added to fuel injected OHRVs. Baseline emissions will include measuring the diurnal, hot soak, running loss, and exhaust emissions for in-use OHRVs as well as new OHRVs. See Appendix A for a complete list of tests to be performed and Appendix C for diurnal temperature profiles. The emissions data will be used to help develop the emissions inventory as well as serve as a baseline value for OHRVs control technology evaluation.

Control Technology Testing

Evaporative emissions testing will include measuring both diurnal and running loss emissions. One piece of equipment from each category will be tested because of the cost and complexity of retrofitting. Of the new OHRVs the Honda CRF 450X off road motorcycle, the Polaris Sportsman 500 ATVs, and a snowmobile (still to be determined) will be evaluated with control technologies. ATVs and off-road motorcycle emissions control technology will include fuel injection and an actively purged carbon canister. Snowmobiles are not operated during ozone non-attainment days; therefore, snowmobiles will be evaluated with only a passively purged carbon canister. Control technologies like fuel injection an actively purged carbon canister and a catalytic converter will not be evaluated on snowmobiles.

Control technologies will be tested by progressively adding control technology, and quantifying the emissions reductions as the technology is added. Technology will be added in the following order:

1. Low permeation fuel tank and fuel line
2. Passively purged carbon canister
3. Fuel injection and an actively purged carbon canister – off-road motorcycle and ATVs only
4. Catalytic converter – off-road motorcycle and ATVs only

The evaporative emissions data generated will be used to help develop an inventory as well as to set evaporative standards for the current regulation being developed. The exhaust emissions data will be used to support a separate exhaust emissions rulemaking at some undetermined time.

Engine Loading for Running Loss Emissions

OHRVs running loss tests will be performed using the same load profile as those currently used for exhaust testing. Off road motorcycles will be tested per the Urban Dynamometer Driving Schedule found in 40 CFR part 86, Appendix I. ATVs will be tested using SAE J1088 unless the EPA accepts a new load profile before testing begins (such as the proposed ATVs-8).

In-use Durability Testing

An in-use durability study will be conducted on the off road motorcycle and ATVs after all the emissions control technology has been implemented and tested. The durability testing will help define customer acceptance, real world durability, and ride ability. OHRVs durability will be evaluated over 100 hours of operation. The first 70 hours of operation will be conducted on a dynamometer; the test profile will be followed for an hour at a time with a half hour shut down between runs. During the last 30 hours of durability testing the OHRVs will be operated in the field. During the dynamometer and field durability testing, control technology safety will also be evaluated.

Safety Study

During the safety evaluation, industry representatives from Consumer Products Safety Commissions (CPSC) (pending), California State Fire Marshal, American Motorcycle Association (AMA), and Motorcycle Industry Counsel (MIC)(pending) will evaluate the safety of the OHRVs as a whole and specifically the catalytic converter and the carbon canister. The following is a list of safety concerns and how they will be evaluated:

Issue: Exhaust gas and component temperature increases from catalytic converters.

Evaluation: Exhaust gas and component temperatures will be measured while the OHRVs is on the dynamometer before and after the OHRVs is retrofitted.

Issue: Exothermic reaction during carbon canister loading.

Evaluation: Virgin carbon will be loaded at the fastest reasonable loading rate while the internal temperature is monitored.

Benefit: Reduction of hydrocarbons being emitted into confined spaces.

Evaluation: During SHED testing the reduction of hydrocarbons being released into a confined space during storage will be quantified.

These laboratory tests should quantify the safety concerns. To evaluate the safety of OHRVs in a real world setting industry representatives will be invited to evaluate the OHRVs in the field during the 30 hour field testing. Industry representatives will have access to the laboratory safety results.

Quality Assurance/Quality Control

Testing will be conducted in compliance with the procedures documented in Chapter 40, Part 86, Section 86.107-90 and 96 of the Code of Federal Regulations, and the California Evaporative Emission Standards and Test Procedures for 1978-2000 Model Motor Vehicles. The engineer conducting the testing will validate quality assurance/quality control data for background, recovery and retention checks to ensure that it meets the requirements of 40 CFR Part 86. In addition all fuels used for testing will be evaluated by ARB's Southern Laboratory Branch to ensure they meet CAR and SAE specifications.

SHED temperature data is collected on a minute by minute basis. The engineer conducting the testing will watch the temperature in order to identify temperature data that is operating outside of the given parameters. This temperature data will be flagged by the engineer. The engineer must then determine if the flagged data should be accepted or rejected.

Appendix A

Table 1

ATVs baseline and Inventory testing

All Terrain Vehicles (ATVs)		Baseline and Inventory Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New ATVs 1	0-15	1	x	x	x	
New ATVs 2	15-25	1	x	x	x	x
Polaris Sportsman 500	25-50	2	x	x	x	x
Used ATVs 1	0-15	1	x	x	x	
Used ATVs 2		1	x	x	x	
Used ATVs 3	15-25	1	x	x	x	
Used ATVs 4		2	x	x	x	
Used ATVs 5	25-50	1	x	x	x	
Used ATVs 6		1	x	x	x	

Number of tests: 11

Table 2

Off Highway Motorcycle Baseline and Inventory Emissions Testing

Off Highway Motor Cycle (OHMC)		Baseline and Inventory Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New OHMC 1	0-15	1	x	x	x	
New OHMC 2	15-25	1	x	x	x	
New OHMC 3	25-50	1	x	x	x	x
Honda CRF 450X	50-120	2	x	x	x	x
Used OHMC 1	0-15	1	x	x	x	
Used OHMC 2		1	x	x	x	
Used OHMC 3	15-25	1	x	x	x	
Used OHMC 4		2	x	x	x	
Used OHMC 5	25-50	1	x	x	x	
Used OHMC 6		1	x	x	x	
Used OHMC 7	50-120	1	x	x	x	
Used OHMC 8		1	x	x	x	

Number of tests: 14

Table 3

Snowmobile Emissions Testing

Snowmobiles		Baseline and Inventory Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New Snowmobile #1	NA	1	x	x	x	
New Snowmobile #2	NA	1	x	x	x	

Number of Tests: 2

Table 4

Deterioration Rate Emissions Testing

Deterioration Rate		Deterioration rate Emissions Testing				
Model #	HP range	Number of Tests	Running Loss	Hot Soak	Diurnal	Exhaust
New ATVs 2 after 1 year	15-25	1	x	x	x	x
New OHMC 3 after 1 year	25-50	1	x	x	x	x

Number of tests: 2

Table 5

Baseline Emissions Variation Due to Fuel Type and Temperature

		Fuel Type			
	Polaris Sportsman 500	CE 10	Phase 2 Cert. Fuel With MTBE	Summertime California Pump Fuel	Wintertime Pump Fuel
Temperature Profile	Winter Temperature Profile	x	x		x
	Summertime 65-105	(Part of Emissions Control testing)	x	x	

Number of Tests: 5

Appendix B

Table 6

OHRVs Emissions control Technology Emissions Testing Matrix

	Evaporative Emissions With Low Permeation Fuel Hose And Tank			Evaporative Emissions With A Passively Purged Carbon Canister			Evaporative Emissions With Fuel Injection And An Actively Purged Carbon Canister				Exhaust Emissions With A High Efficiency Catalytic Converter
	Running Loss	Hot Soak	Diurnal	Running Loss	Hot Soak	Diurnal	Running Loss	Hot Soak	Diurnal	Exhaust	Exhaust
ATVs: Polaris Sportsman 500	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Off Road Motorcycle: Honda CRF 450X	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Snowmobile: Model X			xxx			xxx					

Number of Tests: 27

Table 7

OHRVs emissions control technology with Varying Temperature and Test Fuels

		Fuel Type			
	Polaris Sportsman 500	CE 10	Phase 2 Cert. Fuel With MTBE	Summertime California Pump Fuel	Wintertime Pump Fuel
Temperature Profile	Winter Temperature Profile	x	x		x
	Summertime 65-105	(Part of Emissions Control testing)	x	x	
	Annual Average Temperature Profile	x	x	x	

Number of Tests : 5

Table 8

Comparison of Temperature Correction for Annual Average Versus Summertime

		Fuel Type			
	Honda CRF 450X	CE 10	Phase 2 Cert. Fuel With MTBE	Summertime California Pump Fuel	Wintertime Pump Fuel
Temperature Profile	Annual Average Temperature Profile	x	x	x	
	Summertime 65-105	(Part of Emissions Control testing)	x	x	

Number of Tests : 5

		Fuel Type			
	New ATVs 2	CE 10	Phase 2 Cert. Fuel With MTBE	Summertime California Pump Fuel	Wintertime Pump Fuel
Temperature Profile	Annual Average Temperature Profile	x	x	x	
	Summertime 65-105	(Part of Emissions Control testing)	x	x	

Number of Tests : 5

Appendix C

Table 9
Test Temperature Profiles

Hour	65-105 Temp	Off-road Winter Temp	Annual Average Temp
0	65	47.1	55.3
1	66.6	46.2	54.6
2	72.6	45.6	54
3	80.3	45.2	53.6
4	86.1	44.7	53.2
5	90.6	44.4	53.2
6	94.6	44.1	54.3
7	98.1	44.8	56.8
8	101.2	48.3	60.4
9	103.4	53.5	63.8
10	104.9	58.0	66.5
11	105	61.5	68.6
12	104.2	63.8	70
13	101.1	65.2	70.8
14	95.3	65.8	71.1
15	88.8	65.2	70.6
16	84.4	63.0	68.9
17	80.8	59.3	66.2
18	77.8	55.7	63.2
19	75.3	53.2	60.7
20	72	51.5	59
21	70	50.2	57.8
22	68.2	49.0	56.8
23	66.5	48.4	56

Appendix D

Test Procedure: Running Loss/Exhaust, Hot Soak, and Diurnal

Preconditioning

- Fill fuel system with fuel.
- Operate OHRVs at an idle for 15 minutes.
- For brand new OHRVs allow the fuel system to soak with test fuel for 20 weeks at 30 +/- 10 C*
- For in-use OHRVs soak the fuel systems for 4 weeks at 30 +/-10C.
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Testing

- ***Running Loss/Exhaust Emissions***
- Drain the fuel system and fill the fuel tank to 50% with CE10 (phase 2 cert.)
- Start and idle the OHRVs for at least 15 minutes
- Allow the OHRVs to acclimate in the SHED for at least 6 hours*
- Place the OHRVs on the dynamometer in a SHED preheated to 95F, connect plumbing to allow ambient air directly into the engine and exhaust gasses to exit the SHED
- Operate on the “off-road driving cycle” while measuring the emissions from the exhaust and HC from the shed once a minute
- ***Hot Soak***
- Turn off engine and immediately begin measuring hot soak HC emissions at 95F for 90 minutes.
- Measure HC emissions in the SHED every minute
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Diurnal

- ***Remove the OHRVs from the running loss SHED***
- Refill fuel tank to 50%
- ***Move the OHRVs into a variable temperature SHED set to 65F***
- Allow the OHRVs to acclimate for at least 6 hours
- Begin 65 to 105 to 65 degree F 24 hour diurnal.
- Record HC results every minute for the entire profile

*These times may be re-evaluated after preliminary testing.